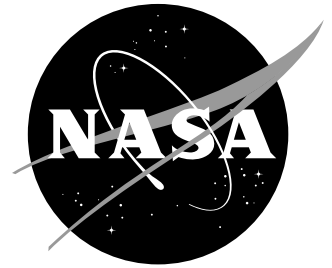


NASA Facts

National Aeronautics and
Space Administration

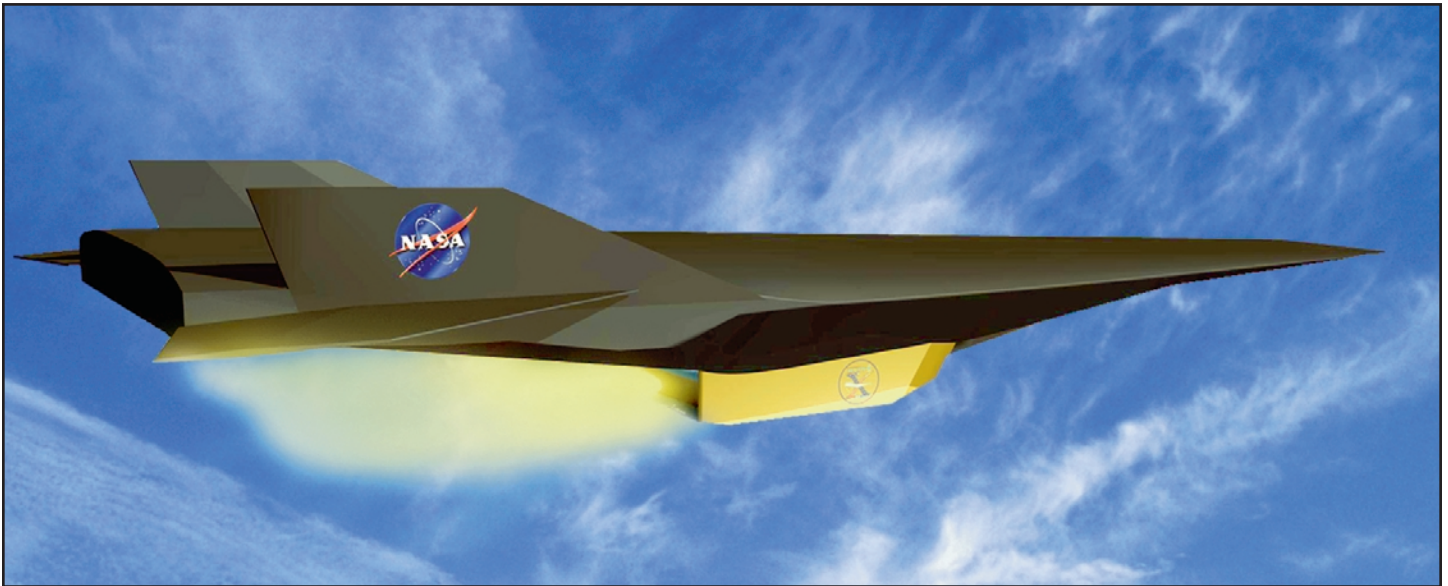
Langley Research Center

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NASA "Hyper-X" Program Demonstrates Scramjet Technologies X-43A Being Readied for Flight



In Phase I of the Hyper-X Program, three 12-foot-long, unpowered aircraft designated X-43A, will fly up to ten times the speed of sound to demonstrate "air-breathing" engine technologies. Each high-flying experimental aircraft will fly once within a test range off the southern California coast.

The NASA multi-year experimental hypersonic ground and flight test program, called Hyper-X, will demonstrate "air-breathing" engine technologies that promise to increase payload capacity — or reduce vehicle size for the same payload — for future hypersonic aircraft and/or reusable space launch vehicles. Built around the program's X-43 research vehicle, the first flight in this technology demonstration program took place on June 2, 2001. It was unsuccessful, due to a rocket booster failure. It was planned to be the first time a non-rocket, air-breathing scramjet (supersonic-combustion ramjet) engine has powered a vehicle in flight at

hypersonic speeds—speeds above Mach 5 or five times the speed of sound. This is equivalent to about one mile per second or approximately 3,600 miles per hour at sea level and far faster than any air-breathing aircraft has ever flown.

As envisioned, payload capacity will be increased by discarding the heavy oxygen and associated tanks that rockets must carry by using a propulsion system that uses the oxygen in the atmosphere as the vehicle flies at many times the speed of sound. Hydrogen will fuel the program's research vehicles, but it requires oxygen from the atmosphere to burn.

Langley & Dryden—A Joint Effort

The Hyper-X Phase I is a NASA Aeronautics and Space Technology Enterprise program being conducted jointly by the Langley Research Center, Hampton, Va., and the Dryden Flight Research Center, Edwards, Calif. Langley is the lead center and is responsible for hypersonic technology development. Dryden is responsible for flight research.

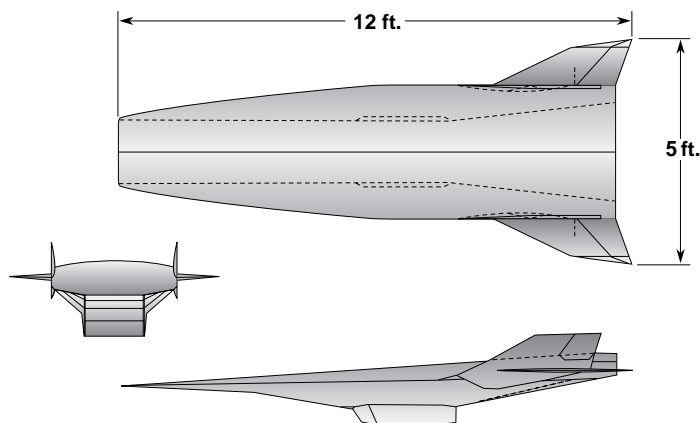
Phase I is a six-year, approximately \$215 million program to flight-validate scramjet propulsion, hypersonic aerodynamics and design methods. Planning for follow-on Mach 5 through 7 flights of a slightly larger X-43 powered by an Air Force Research Laboratory developed hydrocarbon-fueled scramjet is underway. This activity, which is a project under the Marshall Space Flight Center Advanced Space Transportation Program (ASTP), started in October 2001, and plans to fly in 2007.

Research Flights from Mach 7-10

A team led by A²I² (formerly MicroCraft, Inc.) built three unpiloted X-43A research aircraft in support of Phase I.

Research began with conceptual design and wind tunnel work in early 1996. The three lifting-body X-43A aircraft are identical in appearance but are engineered with slight differences simulating engine inlet variable geometry, generally a function of Mach number. Each vehicle is designed to fly once. The first and second vehicles have been designed to fly at Mach 7 and the third at Mach 10. The second flight is planned for summer 2003.

At Mach 10 — or 10 times the speed of sound — the 12-foot-long, 5-foot-wide aircraft will be traveling

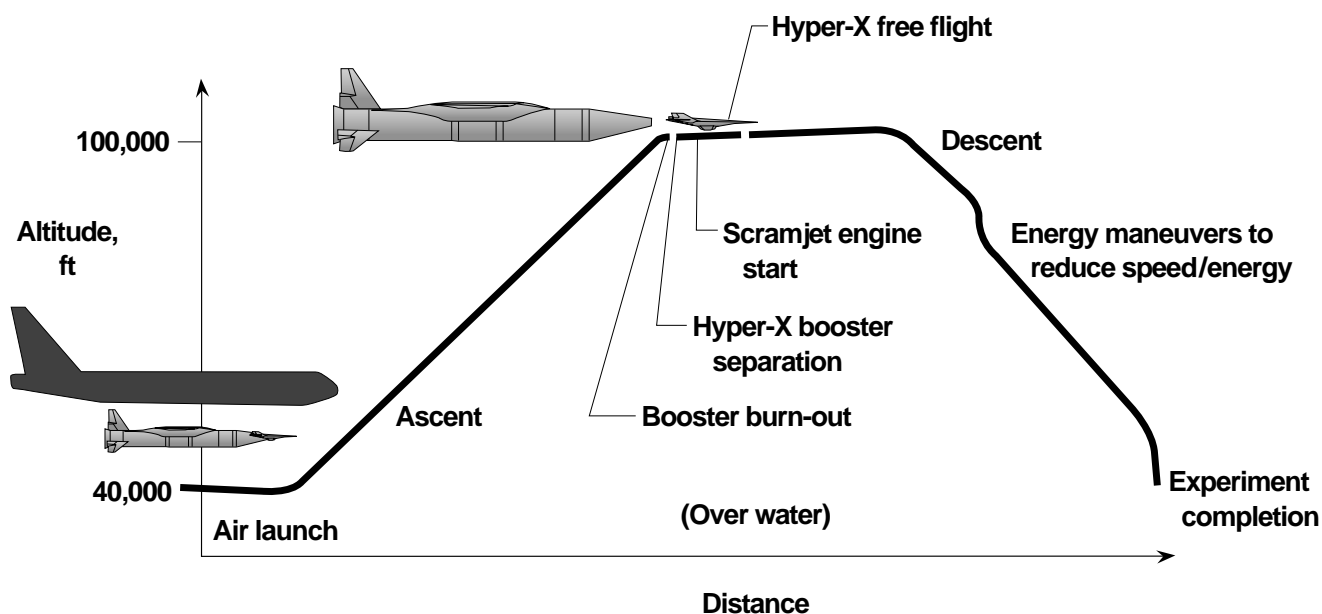


Hyper-X vehicle configuration.

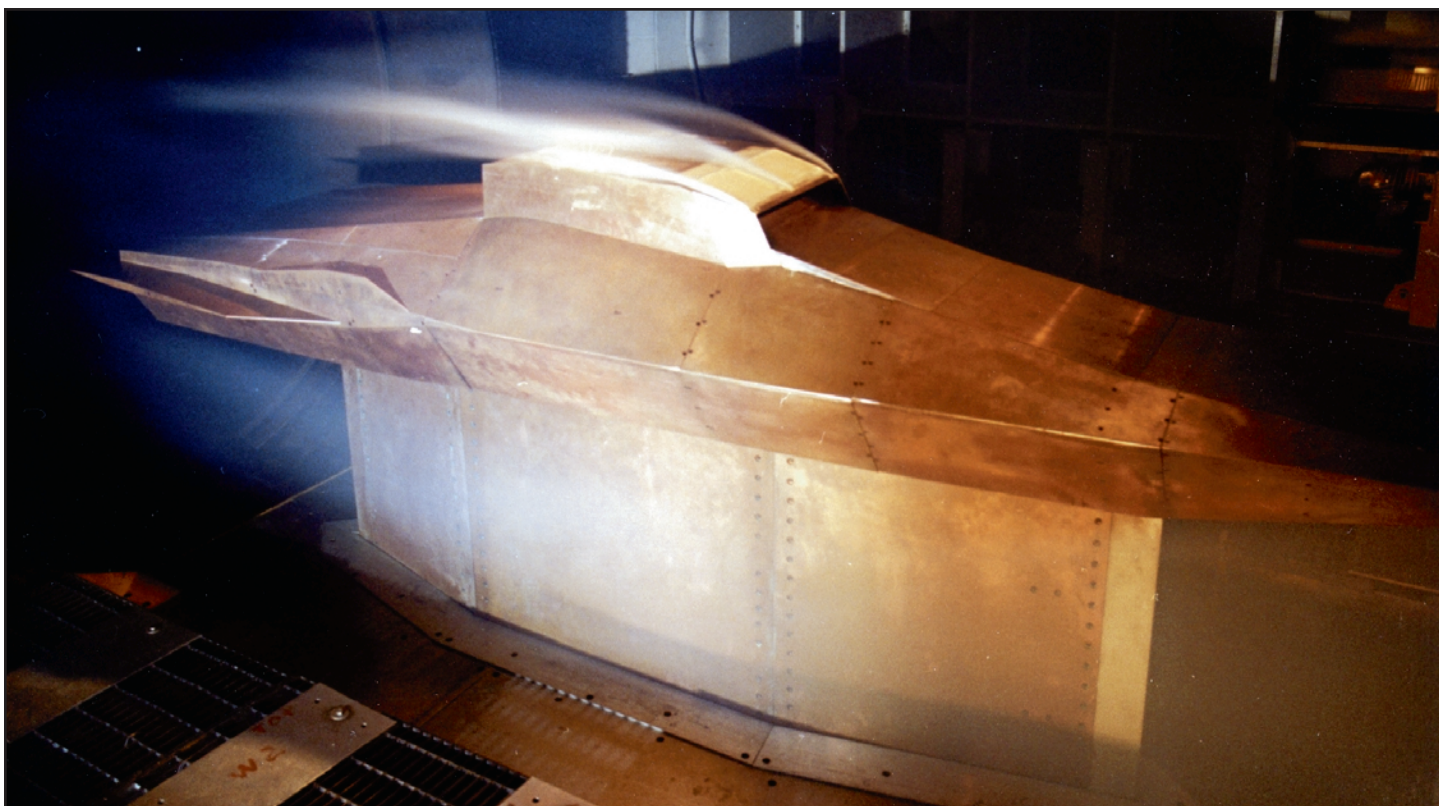
at about two miles per second (approximately 7,200 miles per hour at sea level). Speeds over Mach 5 are defined as “hypersonic.”

Each X-43A will ride on an Orbital Sciences Corp. booster rocket which will be launched by the Dryden B-52. For each flight, the role of the booster is to accelerate the Hyper-X research vehicle to the test conditions at approximately 100,000 feet, where it will separate from the booster and fly under its own power and preprogrammed control.

The Hyper-X research vehicle will be separated from the booster rocket by two small pistons. Shortly after separation, the Hyper-X scramjet engine will operate for ten-plus seconds to demonstrate forward thrust in flight. When the scramjet engine test is complete, the vehicle will go into a high-speed maneuvering glide to collect up to six minutes of hypersonic aerodynamic data while flying to a mission completion point in the Naval Air Warfare Center Weapons Division Sea Range off the southern coast of California.



Each of the Hyper-X research vehicles will achieve test speed and altitude with the help of the NASA Dryden B-52 aircraft and an expendable booster rocket, as shown in this simplified flight trajectory.



Wind tunnel tests show good aerodynamic and propulsion performance for the Hyper-X configuration. Shown here is a Mach 7 test of the full-scale model with spare flight engine in Langley's 8-Foot High Temperature Wind Tunnel.

Vehicle and engine ground tests and analyses are being performed prior to each flight in order to reduce technical risk and to compare with flight test results. This included a spare flight engine which was mounted on a wind tunnel model that accurately represents the size and shape of the full-scale vehicle. The model was tested in Langley's 8-Foot High Temperature Wind Tunnel to verify the ramjet/scramjet propulsion system operability and performance at Mach 7 flight conditions.

First Scramjet Demo Top Goal

This challenging ground and flight research program will significantly expand the boundaries of air-breathing flight by being the first to fly a "scramjet" powered aircraft at hypersonic speeds.

Demonstrating the airframe-integrated ramjet/scramjet engine tops the list of program technology goals, followed by development of hypersonic aerodynamics data and validation of design tools and methods for air-breathing hypersonic vehicles.

A ramjet operates by subsonic combustion of fuel in a stream of air compressed by the forward speed of the aircraft itself, as opposed to a normal jet engine, in which the compressor section (the fan blades) compresses the air. Ramjets operate from about Mach 3 to Mach 6.

A scramjet (supersonic-combustion ramjet) is a ramjet engine in which the airflow through the whole engine remains supersonic. Scramjet technology is challenging because only limited testing can be performed in ground facilities. Hyper-X will build knowledge, confidence and a technology bridge to very high Mach number flight.

Currently, the world's fastest air-breathing aircraft, the SR-71, cruises slightly above Mach 3. The highest speed attained by NASA's rocket-powered X-15 was Mach 6.7. The Hyper-X aircraft will fly faster than any previous air-breathing aircraft.

Glossary of Terms

aerothermal performance. Aerodynamic performance when velocities are high enough for aerodynamic heating to become important (aerothermodynamics).

air-breathing. An aircraft propulsion system which sustains combustion of fuel with atmospheric oxygen.

airframe. Assembled structure of aircraft, together with system components forming integral part of structure and influencing strength, integrity or shape.

airframe-engine integration. The structural and aerodynamic mating of an aircraft's airframe with its engine or propulsion system. In the case of hypersonic scramjet propulsion system concepts, the engine is typically



In this artist's concept, the booster has completed its task of carrying the research vehicle to the test altitude and speed, and the research vehicle has separated from the booster prior to scramjet ignition.

mounted flush to the underside of the airframe in a highly-integrated fashion. The underside of the airframe's forebody is shaped to compress the flow of air into the engine inlet, while the underside of the airframe's aft section is shaped as a nozzle for optimum exhaust flow.

hypersonic. Operation at a Mach number exceeding 5.

lifting body. An aircraft in which most of the lift is generated by the fuselage (as opposed to wings).

Mach number, M. Ratio of true airspeed to speed of sound in surrounding fluid (which varies as square root of absolute temperature). Mach 1 equals the speed of sound, which is 340.294 meters per second or 761.59 mph at sea level (using the 1962 U.S. Standard Atmosphere).

propulsion system. Sum of all components which are required to propel vehicle, i.e., engine, accessories and engine-control system, fuel system, inlet and cooling systems, etc.

ram compression. See ramjet.

ramjet. Air-breathing jet engine similar to a turbojet but without mechanical compressor or turbine; compression is accomplished entirely by ram and is thus sensitive to vehicle forward speed and non-existent at rest.

scramjet. Supersonic combustion ramjet; one in which the flow through the combustor itself is still supersonic.

speed of sound. See Mach number.

trajectory. Flight path in 3-D of any object, eg., an airplane. Can be ballistic, acted on only by atmosphere drag and gravity, or controlled by various external forces.

vehicle configuration. The arrangement of wings, bodies, engines and control surfaces into a vehicle shape.

wind tunnel. A tunnel-like structure through which a test gas is forced at known and controllable velocities, temperatures and pressures to determine the effects of airflow on objects (aircraft, engines or components).

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